DF 1: Focus Session: Conductive Domain Walls

Organisation: Lukas Eng (Technische Universität Dresden)

Time: Monday 9:30–12:15 Location: EB 107

Invited Talk DF 1.1 Mon 9:30 EB 107

Conducting 180° domain walls in PZT thin films — •Patrycja Paruch — DPMC, University of Geneva, Geneva, Switzerland

Following the recent discovery of conduction at ferroelectric domain walls in otherwise insulating BiFeO3 thin films, we have investigated Pb(Zr0.2Ti0.8)O3 epitaxial thin films using atomic force microscopy (AFM) techniques to identify new functional properties. 180° domain walls in this material show not only a piezoelectric shear response forbidden by symmetry in the bulk material, but also present a current signal in conductive tip AFM. The observed domain wall conduction is clearly differentiable from polarization switching currents, and shows highly nonlinear and asymmetric current-voltage characterisitics, strong temperature dependence at higher temperatures, and high stability. Potential conduction mechanisms will be discussed, specifically in relation to the asymmetric nature of the electrodes contacting the ferroelectric thin film, and the microscopic structure of the domain walls promoting defect segregation.

ref: J. Guyonnet et al, Adv. Mat. 23, 5377 (2011)

Invited Talk DF 1.2 Mon 10:00 EB 107

Charged Domain Walls and Their Impact on Properties of Ferroelectrics — •Alexander Tagantsev — Swiss Federal Institute of Technology

A ferroelectric domain wall can carry net bound charge depending on its orientation with respect to the direction of polarization in adjacent domains. The properties of such walls, called charged walls, can substantially differ from those of walls which carry no bound charge. An essential feature of this kind of walls is that, practically, they can exist only when their bound charge is nearly fully screened by free carriers in the material.

This paper is devoted to the theory of properties (structure, mobility, and conductivity) of charged ferroelectric domain walls and that of the impact of this kind of walls on the dielectric and piezoelectric properties of the material. Available experimental data will be discussed in the context of the theories presented.

Topical Talk DF 1.3 Mon 10:30 EB 107

UV-induced domain wall conductivity in Lithium Niobate single crystals — Mathias Schröder, •Alexander Haussmann, and Lukas M. Eng — Institute of Applied Photophysics, Technische Universität Dresden, D-01062 Dresden, Germany

For the last years, electronic conduction at ferroelectric domain walls (DWs) in thin films has triggered extensive research activities regarding possible nanoelectronic applications [1,2,3]. Here, we show that this effect is not restricted to thin film systems, but can be observed in highly insulating bulk single crystals as well, according to theoretical predictions [4]. In ferroelectric lithium niobate, DW conductivity can be switched and adjusted by super bandgap illumination ($\lambda \leq 310$ nm) within a broad intensity range at room temperature. Furthermore, we demonstrate that this photo-induced DW conductivity can be elegantly tuned by engineering the tilting angle of the DWs with respect to the polar axis. Our experimental results were obtained using conductive atomic force microscopy (c-AFM) under UV illumination to map the DW conductivity with a resolution in the nm range.

[1] J. Seidel et al. *Nat. Mater.* **8**, 229 (2009).
[2] S. Farokhipoor et al. *Phys. Rev. Lett.* **107**, 127601 (2011).
[3] J. Guyonnet et al. *Adv. Mater.* **23**, 5377 (2011).
[4] M. Y. Gureev et al., *Phys. Rev. B* **83**, 184104 (2011).

5 min. break

Invited Talk DF 1.4 Mon 10:55 EB 107

Mechanisms and control of conduction through domain walls in $BiFeO_3$ thin films — •Saeedeh Farokhipoor and Beatriz Noheda — Zernike Institute, Univ. of Groningen, The Netherlands

$BiFeO_3$ (BFO) has become widely popular not only because it is the only room temperature, antiferromagnetic ferroelectric, but also because of the interesting sequence of phase transitions that it can display. In BFO thin films under epitaxial strain different types of domain walls can be obtained with very high control, which has allowed systematic investigation of the distinct properties of domains walls. It was revealed that artificially-written 109^o and 180^o domain walls in BFO thin films show enhanced conductivity with respect to the domains[1]. This promises to enable novel nano-devices and has initiated further work on the mechanisms that control ferroelastic domain wall conductivity in BFO[2,3] and other ferroelectrics[4,5]. Here we show that highly-stable, as-grown, 71^o domain walls of BFO conduct as good as or better than written 109^o walls and that the main mechanism for conduction is thermionic emission of electrons from the top electrode (the conductive tip of an atomic force microscope). The tunability and control of the current by engineering the tip-BFO Schottky barrier using various routes will also be discussed.

[1] J. Seidel et al. Nat. Mat. 8, 229 (2009); [2] J. Seidel et al. Phys. Rev. Lett. 105, 197603 (2010); [3] S. Farokhipoor and B. Noheda Phys. Rev. Lett. 107, 127601 (2011); [4] P. Maksymovych et al. Nanotechn. 22, 254031 (2011); [5] J. Guyonnet et al. Adv. Mater., DOI: 10.1002/adma.201102254

Invited Talk DF 1.5 Mon 11:25 EB 107

Domain wall functionality in complex oxides — •Jan Seidel — Lawrence Berkeley National Laboratory, Berkeley CA 94720, USA

Interfaces and topological boundaries in complex oxide materials, such as domain walls, have recently received increasing attention due to the fact that their properties, which are linked to the inherent order parameters of the material, its structure and symmetry, can be completely different from that of the bulk material. I will present recent results on electronic and optical properties of ferroelectric domain walls in multiferroic BiFeO3 and ErMnO3. The origin and nature of the observed electrical conductivity at certain wall types is probed using a combination of conductive atomic force microscopy, high resolution transmission electron microscopy and first-principles density functional computations.

Topical Talk DF 1.6 Mon 11:55 EB 107

Photoinduced electrical transport properties of LiNbO3 single crystals — •Andreas Thiessen[1], Alexander Haussmann[1], Mathias Schröder[1], Theo Woike[2], and Lukas M. Eng[1] — [1]Institut für Angewandte Photophysik, Technische Universität Dresden, D-01062 Dresden — [2]Institute of Structural Physics of Condensed Matte, Technische Universität Dresden, D-01062 Dresden,Germany

Both the photo-induced electronic transport and the photovoltaic properties of domain walls (DWs) have triggered an increased interest in bulk and thin-film ferroic materials [1,2]. Technologically, the electronic behavior of domain walls in bulk LiNbO3 (LNO) single crystals are of special interest due to the availability of large-scale LNO wavers and the possibility of photolithographic domain wall engineering in these materials [3]. In the present work the transport properties of macroscopically contacted LNO were investigated. The temperature and illumination dependence of the electrical conductivity will be discussed, paying particular attention to the microscopic transport mechanisms and activation energies needed for transport within the domain wall regions.

[1] J. Seidel et al., Nat. Mater. 8, 229-234 (2009).
[2] J. Seidel et al., Phys. Rev. Lett. 107, 126805 (2011).
[3] A. Haußmann et al., Nano Lett. 9, 763-768 (2009).